Crop model calibration for improving simulations of regional impacts of climate change in Europe

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Background and Methodology

Introduction

Projected Climate Change (CC) will affect the productivity of crops in Europe but the extent and variability of climate impacts are not well understood for different crops and regions. Crop models are increasingly used for large scale applications but require adequate model calibration for the crops and regions considered which is time consuming and data intensive. Also, an extension of these models is needed to consider effects of both CC and technology development.

The present study aims to assess the importance of a region-specific calibration of crop phenology and selected growth parameters for yield simulations of representative winter and spring crops across the 25 member countries of the European Union (EU25) between 1983-2006. This poster presents selected results for winter wheat and maize of:

1. Comparison between three calibration methods for EU25 and
2. Simulated spatial and temporal crop yield variability under climate and technology change for a future time period centered on 2040.

Calibration Methods

- Simulations performed with FAST (Fast Agro-Simulation Technique) based on Lintul-2 (van Ittersum *et al.*, 2003) implemented in ACE (ACE-FAST), a further development of the modelling framework APES (Donatelli *et al.*, 2010).
- Brute-force search algorithm generator to calibrate phenology and selected model crop growth parameters.
- Tested calibration methods:
  - (1) Region-specific calibration of phenology parameters only.
    - Temperature sums for 555 climate zones across EU25 (Andersen *et al.*, 2009) calibrated on crop calendars (European Union Statistics, 2004).
    - One growth parameter set per crop for all EU25 regions.
  - (2) As method (1) plus use of a correction factor for yield estimations.
    - Phenology calibration as in (1).
    - Calculation of yield correction factor (Therond *et al.*, 2011) for each of the 555 climate zone, i.e. one correction for each climate zone.
  - (3) As method (1) plus calibration of three growth parameters.
    - Phenology calibration as in (1).
    - Calibration of three growth parameters; radiation use efficiency, specific leaf area and drought tolerance for each of the 555 climate zones.

Results

Effect of calibration method

- Method (1) shows no relationship between observed an calibrated yields (Fig. 1a).
- Method (2) improves calibration results significantly (Fig. 1b).
- Best results were obtained with method (3) (Fig. 1c).
- Temporal yield variability is well reproduced with method (3) (Figure 2a).
- Spatial yield variability is also well reproduced with method (3) (Figure 2b).

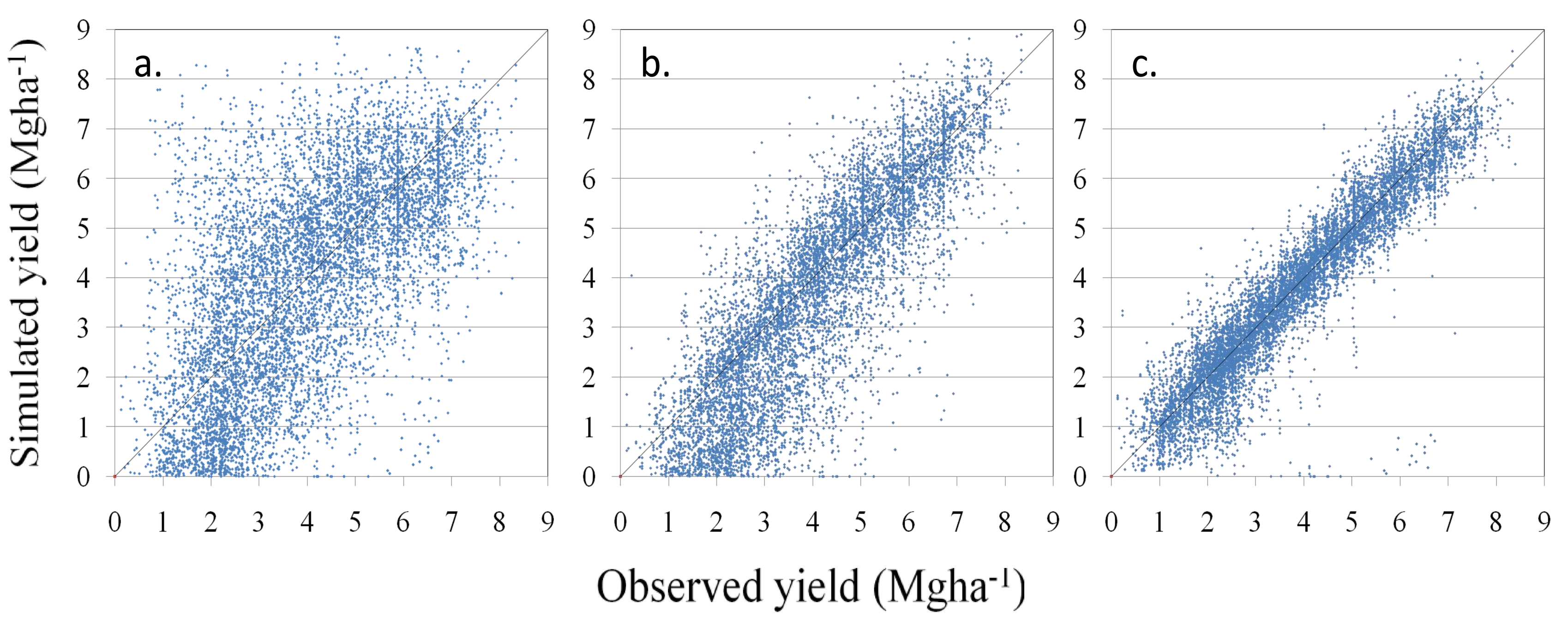

Figure 1. Comparison between observed and calibrated winter wheat yields for three calibration methods a) method (1), b) method (2) and c) method (3) for 555 climate zones in Europe in the period from 1983 to 2006.

Results

Effect of calibration method

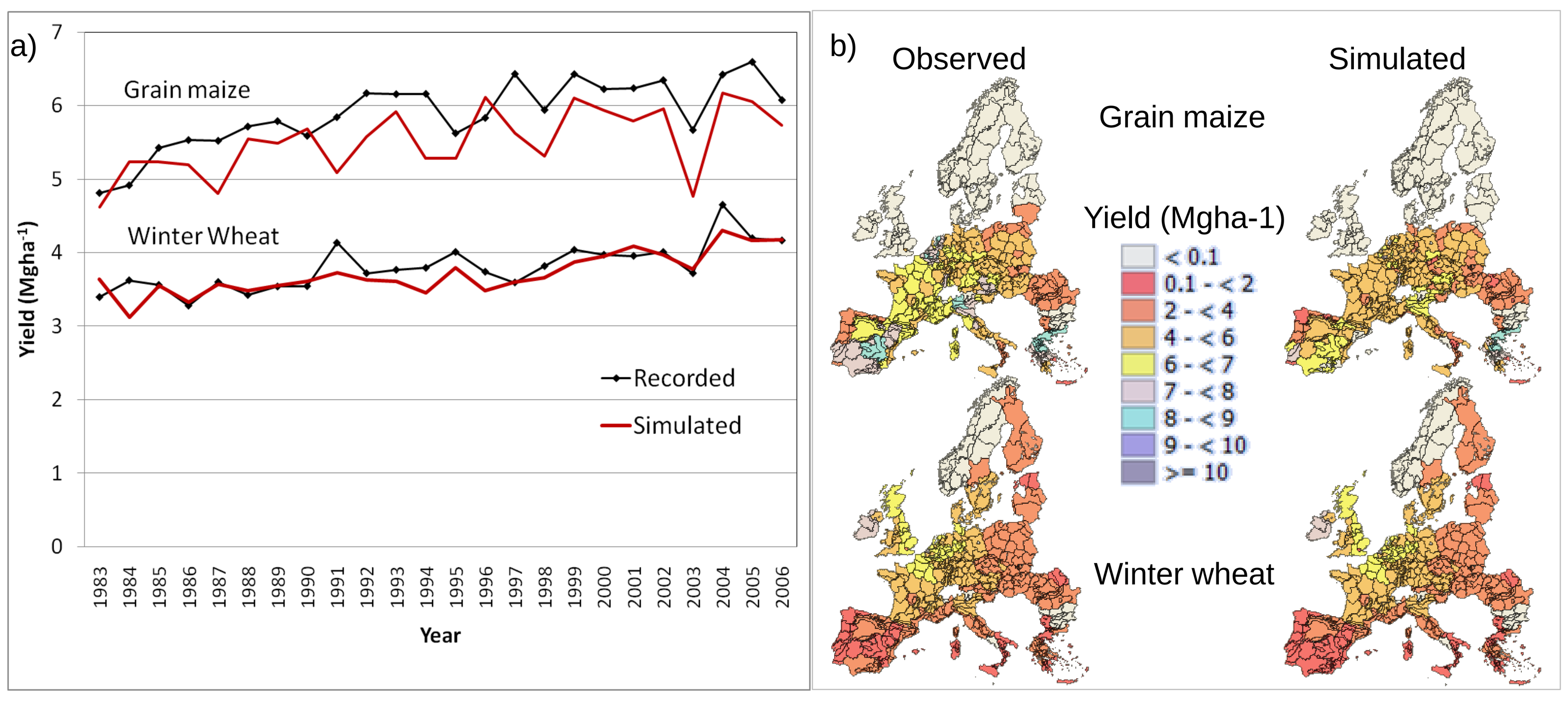

Figure 2. Comparison of observed and simulated (a) temporal and (b) spatial variability of winter wheat and grain maize yields (Mgha-1).

Simulation of climate change effects

- Climate change in combination with elevated CO_2 increased yields for A1B, A2, B1 and B2 IPCC CC scenarios derived from four climate models (Fig. 3a).
- Consideration of technological development (Ewert *et al.,* 2005) resulted in largest projected yield increase and increased differences between scenarios (Figure 3b).
- There was a spatial variability in projected yield changes which also differed among crops (Fig. 4).
- Calibration method affects simulations of climate change effects (not shown).

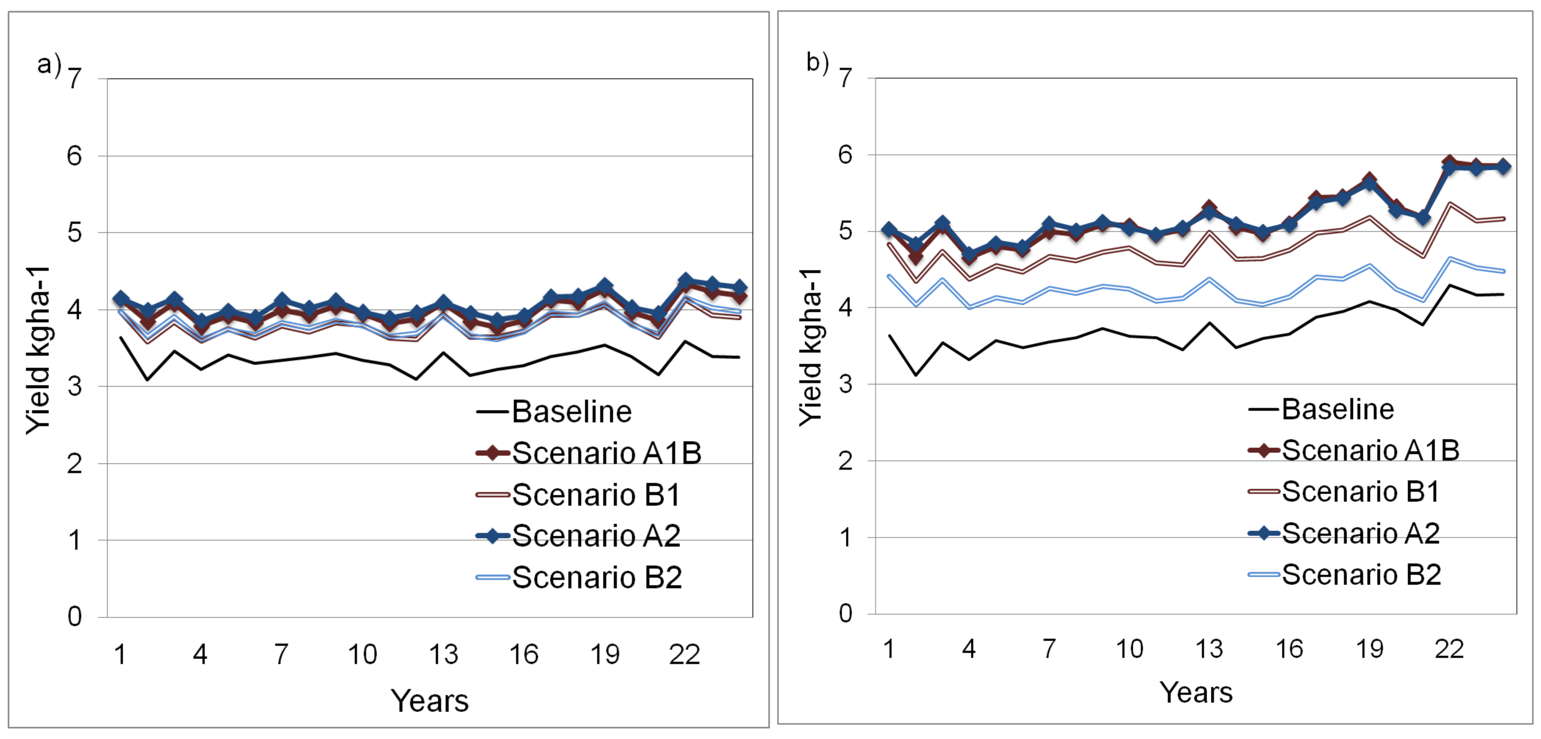

Figure 3. Simulated effects of (a) climate change and elevated CO_2 and (b) climate change elevated CO_2 and technological development on yields of winter wheat for 23 years in Europe using four IPCC scenarios. The baseline and future time series are centered around 1990 and 2040, respectively.

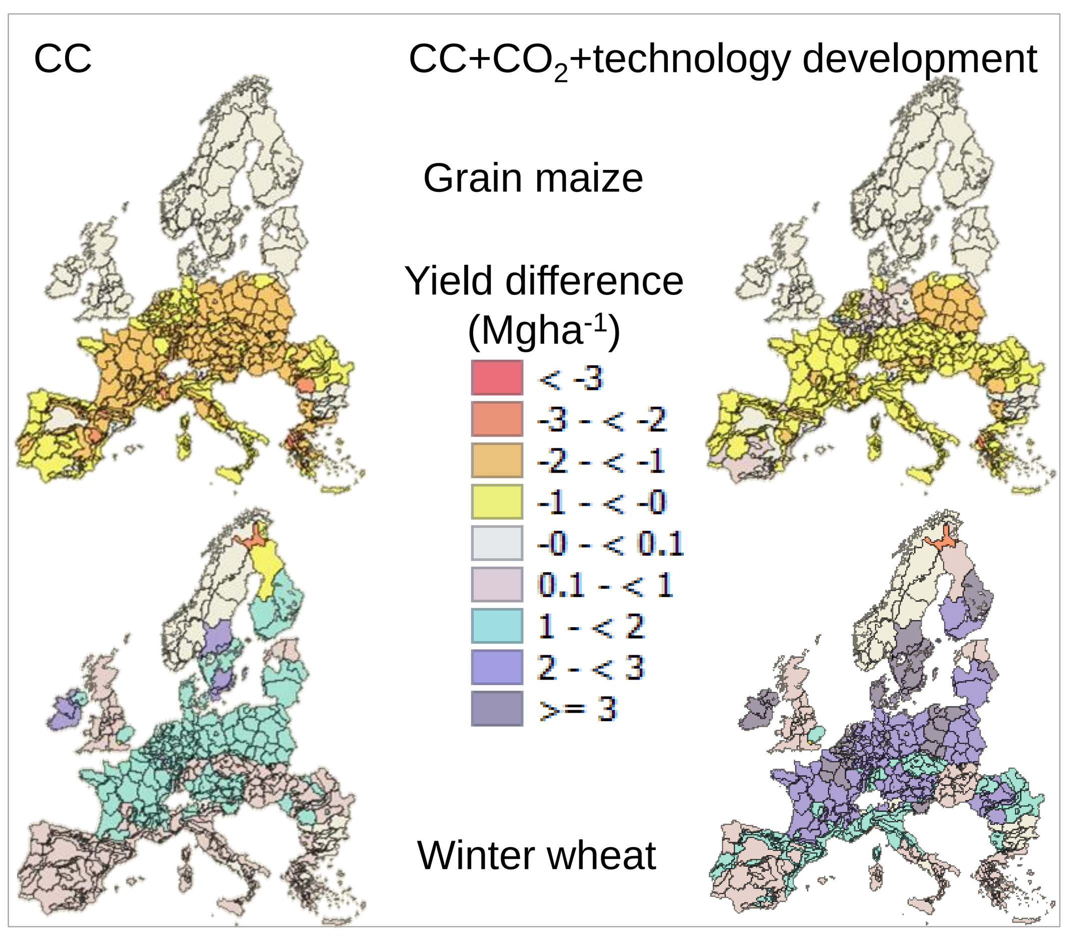

Figure 4. Differences between simulated baseline and A1B CC scenario maize and wheat yields. Left hand side shows the only CC effect and right hand side the technological development assumed together with the CC scenario A1B.

Conclusion and outlook

- Regional calibration of phenology and growth parameters crop simulation models can satisfactorily reproduce large-scale yield variability.
- Effects of climate change and elevated CO_2 on projected yield changes are relatively small compared to effects of technology development.
- Future work should provide information about the uncertainty of model parameters
- Consistent linking (with respect to the process detail) of the effects of CC and technology development on crop yield also needs further attention.

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